An integrated and sustainable solution to ensure in-section dust compliance

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Paper written on project work carried out in partial fulfillment of B Eng degree

Synopsis

Optimization of current control systems, proper maintenance and efficient training of personnel are recommendations made to control the amount of dust that underground employees are exposed to on a daily basis in the coal mining industry.

This dissertation forms as part of Sasol Mining's commitment to protect the health and safety of their employees by suppressing and controlling dust at their mines. This study aims to understand the relationship among mining processes, exposure to dust and dust suppression control measures.

The research phase of the project was done at the Sasol Mining Secunda complex where underground visits were undertaken to investigate current control systems and also new systems that are being implemented by Sasol Mining. This work was important because it helped determine the sources of dust underground and also to identify the shortcomings of current control systems and to test the efficiencies of the new systems implemented at Sasol Mining.

The most important result of the research work was the identification of which underground operators were exposed the most to dust as this assisted in designing a dust suppression system for the areas where these operators worked.

The main conclusions of this study are that the current control systems are sufficient for controlling dust and ensuring dust compliance if they are used efficiently and maintained properly.

Motivation for this study

Mine background and general information

Sasol Mining is an integral part of the Sasol Group of companies and is responsible for producing and supplying over 50 million tons of coal a year, mostly to the Sasol plants at Sasolburg and Secunda, South Africa, and to international customers. The company has two regional operations:

- ➤ Sigma Colliery, near Sasolburg
- ➤ Secunda Collieries, located in Mpumalanga and consisting of five underground operations at Secunda and the Syferfontein underground mine near Trichardt.

The following are the names of all the major operational Sasol mines.

- ➤ Bosjesspruit Colliery
- ➤ Brandspruit Colliery
- ➤ Middelbult Colliery
- ➤ Twistdraai Colliery
- ➤ Syferfontein Colliery
- ➤ Sigma Colliery.

Secunda coalfield

The No. 4 lower seam is being mined, and the depth varies between 90 and 180 metres below surface. The seam height varies from a minimum of less than 2.0 metres to a maximum height of 6.0 metres, with an average of 3.0 metres. The flammable gas content ranges between 0.23 and 2.43 m^3/t in burnt coal, with the average for the complex at 0.98 m^3/ton mined. The flammable gas release rate varies between 2.5 and 144.8 litres/ton/min (ℓ/t/m) with the average for the complex at 22.9 ℓ/t/min. The CV and ash content of the coal seam are 22.8 MJ/kg and 25.4 % respectively (Sasol Mining COP, 2006).

Sasolburg coalfield

The No. 2B and 3B seams are being mined, and the depth is 56 metres below surface. The seam has a maximum height is 9.8 metres with an average of 2.8 metres. The flammable gas content ranges between 0.00 and 0.02 m^3/t mined. The calorific value (CV) and ash content of the coal seam are 20.2 MJ/kg and 25.7% respectively (Sasol Mining COP, 2006).

Mining methods

The following methods are practised by the Sasol mines.

- ➤ Board and pillar sections mined with single or double continuous miners, battery haulers or shuttle cars, as well as continuous haulages
- ➤ Pillar extraction and pillar splitting by means of continuous miners; this is at selected mines only

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- Conventional mining where the coal-seam is mined by drilling and blasting operations, also at selected mines
- Drill and blasting operations when geological disturbances necessitate this method.

Ventilation arrangements

Each colliery is ventilated independently with main fans, and upcast and downcast shaft systems. Individual sections are ventilated using jet fans and auxiliary fans.

Project background

Prior to July 2005, the Department of Minerals and Energy (DME) required that coalmines keep their average dust readings per month less than 5 mg/m^3 at the position of the continuous miner (CM) operator and a dust concentration of less than 2 mg/m^3 on personal sampling performed on the operators. All Sasol Mining mines were complying with this regulation, but after 1 July 2005 a directive by the DME was that the dust readings were to be kept below 5 mg/m^3 on 90% of all the samples taken. This is when the mines in the coal-mining industry started not complying with the standard guidelines, they complied with the average of 5 mg/m^3 compliance directive but not the new 90% compliance directive.

Dust readings need to be kept at their lowest for the following reasons.

- To protect the health of employees and prevent illnesses such as tuberculosis, silicosis, etc.
- To prevent coal dust explosions
- To avoid penalties from the DME for not complying with regulations
- To reduce accidents by improving visibility underground.

Figure 1 indicates average dust readings for all Sasol Mining mines from 2001 to 2006. It also shows the readings over 2006. It can be seen from the figure that the mines have been complying with the average of below 5 mg/m^3 directive but not always with the 90% compliance directive. The figure also shows dust averages per year from the year 2000 to 2005 to the left of the black line that breaks the graph.

Figure 2 shows the number of continuous miners (CMs) not complying with the 90% compliance directive. In November 2006, 20 CM sections were not complying. However, this figure has significantly improved: by the end of 2007 less than 5 CM sections were not complying.

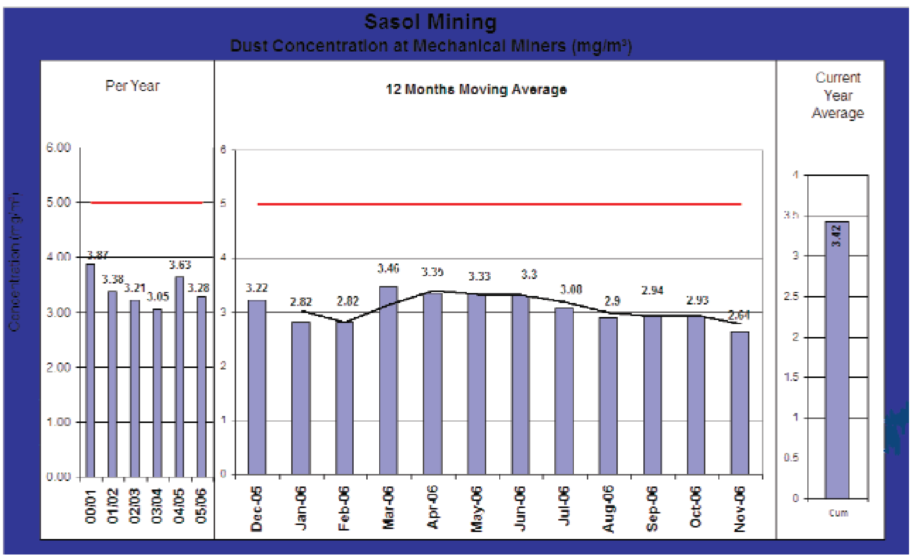


Figure 1—Average dust readings for all Sasol mines

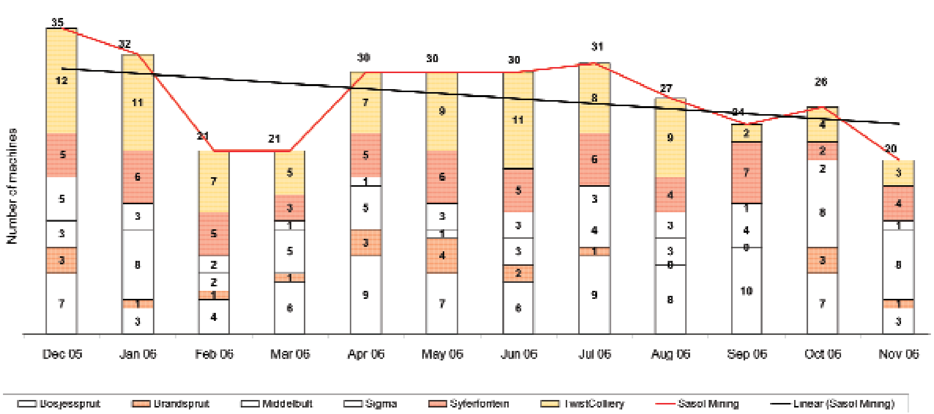


Figure 2—Number of CMs below 90% compliance per mine

Table I

Number of CMs in each mine

Middelbult	Brandspruit	Syferfontein	Sigma	Twistdraai	Bosjesspruit
9	10	10*	3	12**	10

* Syferfontein has 7 CM sections and 3 Voest sections but the dust readings are taken on all sections.
** Twistdraai has 3 mines: Twistdraai East (4 CMs), Twistdraai Central (3 CMs) and Twistdraai West (5 CMs).

Table I shows how many CMs each one of the Sasol Mining mines had in December 2006.

As part of Sasol Mining's health management plan, all underground employees are tested annually for occupational lung diseases. This is done as part of the personal dust exposure monitoring programme and to determine the effects that overexposure might have. The monitoring programme also helps to identify cases where medical treatment for TB is required. Sasol Mining aims to have no further employees infected with any occupational lung diseases.

This report will illustrate a design of sustainable solutions, which can be integrated within the already existing dust suppression system and infrastructure and can be implemented in all sections to assist in controlling dust, thus helping the mine comply with legal requirements. This forms part of Sasol Mining's initiatives against occupational lung diseases.

Current systems being used by Sasol Mining are as follows:

- ➤ The use of directional sprayers mounted on the CM
- ➤ The use of a scrubber
- ➤ Ventilation methods, which course the air in the section
- ➤ Water sprayers on the feeder breaker and on conveyor belts.

These systems will be discussed in detail below and their shortcomings highlighted.

Problem statement

An integrated and sustainable solution to ensure in-section dust compliance for Sasol Mining.

Objectives and methodology

Scope of work

The project has the following limitations.

- ➤ The project is limited to only continuous cutting sections using the board and pillar cutting method
- ➤ The project is limited to the Sasol Mining Secunda mines only as the Sasolburg mines differ geologically from the Secunda mines and have been complying with legal requirements
- ➤ Solutions have to be able to be integrated within Sasol Mining dust suppression systems and infrastructure.

Literature survey

Introduction

The previous section explained the need for the investigation and the following objectives were identified:

- ➤ Identifying sources of dust in a sections
- ➤ Investigation of current control systems
- ➤ Investigation of new systems and technology
- ➤ Data analysis on personal sampling for operators
- ➤ Find solutions that are sustainable and can be integrated within the existing systems.

This chapter is a summary of past work and research that has been done concerning the control and suppression of dust in collieries. This section will follow the following sequence:

- ➤ Legal requirements pertaining to dust
- ➤ Dust control systems
- ➤ Literature on current control systems
- ➤ Literature on new systems and technology.

Legal requirements

Mine Health and Safety Act

All mine owners, mine managers, mine employers and employees are bound by the Mine Health and Safety Act of 1996, which lists the responsibilities of the above individuals in maintaining a healthy and safe working environment for themselves and their colleagues(MHSA, 1995).

DME directives

A directive by the DME (1997) enforced a maximum dust-concentration level of 5 mg/m^3 on the average monthly sampling results on the CM. This was due to the high concentrations of dust in personal sampling for the CM operator.

Furthermore, in 2005 this directive was amended and now the new directive was that dust concentrations need to be below 5 mg/m^3 on 90% of the samples taken underground per month (Dawid, Belle, 2005).

Table II

Objectives and methodology

Objectives	Methodology
Identify sources of dust in a section	Going on site (underground) and testing through sampling
Investigate current systems and their effectiveness and also highlight their shortcomings.	Consulting with environmental personnel and going on site underground and collecting data to research the effectiveness of other mines.
Investigate new systems and technology that are being introduced to Sasol Mining for long-term suppression of dust.	Consultation with mine environmental personnel and manufacturing companies and data analysis.
Analyse data on personal sampling done at the mine to illustrate the degree to which operators are exposed to dust.	Analyse personal sampling data from Colliery Environmental Control Services (CECS) who analyse Sasol Mining dust samples.
Find sustainable and integrated solutions for reducing in-section dust readings.	Research and consultation with experts, i.e. mine environmental personnel.

An integrated and sustainable solution to ensure in-section dust compliance

A guideline was issued by the DME in 2002 to help guide mines with compiling of a code of practice (COP) for personal exposure to airborne pollutants. All mines had to compile the COP and see it through to implementation. The guideline also demanded an implementation plan from the mine (Mine Health and Safety Inspectorate, 2002).

Industry milestones

At the Mine Health and Safety Summit on 24 October 2003 the then Minister of Minerals and Energy, Phumzile Mlambo-Ngcuka, stated that further improvements were needed in health and safety in the South African mining sector, with silicosis a major concern. The Summit agreed that milestones for the elimination of silicosis needed to be set. The agreed milestones are:

- By 2008, 95% of all exposure measurements results will be below the occupational exposure limit (OEL) for respirable crystalline silica of 0.1 mg/m^3. These results are individual readings and not averaged results
- From 2013, using present diagnostic techniques, no new cases of silicosis will occur among previously unexposed individuals.

These milestones in simple mining terms mean that from December 2008 all dust samples that are analysed should further be analysed for crystalline silica, a compound formed by silicon (Si) and oxygen (O) atoms. The crystalline silica of the sample should be less than 0.1 mg/m^3. This is the MHSA Occupational Exposure Limit (OEL) for respirable quartz for an employee working a full shift (8 hours).

Furthermore, no previously unexposed individuals who entered the mining industry after 2008, should contract silicosis.

The significance of the available information

The information shows regulations with which Sasol Mining must comply and also standards that should be used to measure the level of success of solving the problem addressed in this report. Success will be defined by when the Sasol Mining mines comply with the legal requirements and are also following and complying with the industry milestones.

Dust control systems

Summary of minimum dust control measures

The report by the Mine Safety and Health Administration in Pittsburgh illustrates the importance of the 'System Approach', it also introduces the concept of secondary and primary sources of dust in a typical coalmine. The most important secondary source of dust is the actual cutting of the coal by the CM. Primary sources include: dust in intake airways, dust at transfer points (feeder breakers and conveyor belts), dust generated in the bunkers, dust generated by roofbolting operations and dust in the crushers. The MHSA document explains the mechanism of dust .

The importance of the available information

This paper provides an approach to identifying the sources of dust underground and also the classification of the sources. In Sasol Mining the secondary sources of dust are the actual cutting of the coal and transfer points. Primary sources are the intake airways, travelling roads and the conveyor belts. With the sources of dust identified, the next step will be finding dust suppression methods for the sources. Coal dust must be supressed at the source before it becomes airborne as it is more difficult to suppress once it becomes airborne. This approach can be implemented at Sasol Mining by optimizing solutions that suppress dust at the source.

Dust control in coalmines

The South African Mining Industry Best Practice on Prevention of Silicosis report introduces the 'Systems approach' to dust control in coalmines. The document introduces all components of the dust suppression system in a coalmine.

There is a combination of dust control systems required on continuous miners to suppress and control dust created by the CM. The most commonly used ventilation and dust control systems for CMs are on-board scrubbers, water sprays, water-powered air movers and auxiliary ventilation systems such as brattices, jet fans, and force ventilation.

Scrubbers mounted on the CM collect dust-laden air through an inlet near the front of the CM, wet the dust down and discharge cleaned air at the back of the CM. The most commonly used scrubbers in South African coalmines are of the wet fan design. Inside the scrubber, the dust-laden air passes over a fan and water spray arrangement that remove dust via the centrifugal force created by the fan motion. It then passes through a knit wire mesh panel that is wetted with water sprays, which causes the dust particles to be captured by the water. After passing through the filter panel, the air stream then enters a demister, which removes the dust-laden water droplets from the airstreams. The cleaned air is discharged at the back of the scrubber unit. Brattices, jet fans and force fans are used to course the direction of the air underground and to dilute dust-laden air (David and Belle 2005)

The significance of the available information

This Belle report introduces and highlights the importance of the different components of the dust suppression system. The report is a general overview of what the dust suppression system should consist of in all coalmines and helps in identifying its crucial components.

Current control systems

Reduction of worker exposure to dust in collieries

The report Reduction of worker exposure to dust in collieries, by Oberholzer (1996) was funded by SIMRAC and had the main objective of evaluating current dust suppression systems. The project identifies the following components of the dust suppression system:

- Scrubber efficiencies
- Jet fans in different positions
- Jet fans in semi-series and with a force fan
- Variations of last through road (LTR) velocities

The main findings of the project were as follows:

- As the relationship between dust entering the inlet and dust removed by the scrubber for an underground section were between 40–90% and at a surface gallery

ranged from 90–97%, it was concluded that scrubber efficiencies were more than adequate to suppress dust. Therefore more focus should be put on the other components of the dust suppression system
- Air quantities delivered by auxiliary ventilation should balance to control recirculation and rollback
- The outlet of the scrubber should be directed in such a manner that the outlet air reached the LTR in the shortest time to avoid recirculation and without interrupting with the shuttlecar operator
- The distance of auxiliary ventilation should 10–15 m from the face to suppress dust
- Splits should be ventilated by means of force ducting
- The inlet of exhaust scrubber should be as close as possible to the face
- Jet fans in semi-series with or without ducting should be completely avoided
- The directional spray system is essential for good airflow and good dust control.

The significance of the available information

It introduces the different components of the current control measures all of which are currently being used by Sasol Mining mines. The report provides guidelines on how to ensure that the current dust suppression system is being utilized efficiently.

Dust improvement plans

This initiative was implemented by Sasol Mining as part of its initiatives to control dust. This plan is an interactive approach that involves all underground mine personnel doing their part when it comes to controlling dust. The plan has the following focus:
- Personal attitude towards safety and health—all personnel must know about the plan and perform dust audits as stipulated by the plan
- Communication—this is to ensure the communication of daily results with the underground
- Optimize existing systems—on the intake airways and on the CM (the water sprays and the scrubber)
- Coaching and Training—occupational hygiene department, continuous improvement (Vuselela) personnel and safety officers to provide constant training for underground employees
- Governance—the importance of governance with each person's role and responsibility clarified.

The significance of the available information

An interactive approach such as this is important because it motivates all individuals working towards the same goal, thus increasing the chances of that goal being reached. This approach was initially a Twistdraai initiative and has shown good results, as will be discussed later. Its success has shown that it is sustainable and has already been employed in all Sasol mines.

New systems and technology employed at Sasol mining

Wet-head system vs. directional spray system

CSIR Mining Technology evaluated the effectiveness of a wet-head (WH) and directional spray fan (DSF) dust-suppression system on a continuous miner (CM) at Vlaklaagte Mine of Goedehoop Colliery. The aim of the evaluation was to illustrate the effectiveness with which the Joy WH system and the SF system control the respirable dust around an operational CM. Table III shows the parameters of the section where the evaluation was carried out.

The DSF system consists of with 21 hollow-cone sprays mounted on the boom, facing the cutter head. There are 12 directional sprays on the top of the boom, three horizontal sprays facing downwards on the air-intake side of the boom, and three vertical sprays facing forward on either side of the boom.

The CM is fitted with a type-24 Engart scrubber, displacing 8 m^3/s. The outlet of the scrubber blows towards the sidewall.

The major difference between the directional DSF system and the WH system is that the instead of the sprays on the boom, in the WH system water is directed to the sprays situated at the back of each of the picks on the cutter head. The WH consists of 63 picks on the cutter head and water sprayers on each pick, as illustrated in Figure 3 and Figure 4.

Some of the conclusions of the evaluation were as follows:
- From the respirable dust levels recorded, normalized for production (based on shuttle cars), it was found that the WH dust-suppression system controlled respirable dust levels at the cabin position of the CM more effectively than the SF system during the test period.
- Over the test period the average respirable dust levels recorded per shuttle car loaded at the CM operator's position for the WH system were about 50 per cent lower compared to the SF system
- Throughout the test production rates were similar for both the WH and the DSF system; however, the DSF system cut about 50% more splits than the WH system (Van Zyl, 2005)

The significance of evaluation

Sasol Mining has also implemented the wet-head cutter system at Brandspruit 2 shaft, section 29 and it is still in the trial period. The above-mentioned information has proven that the WH system does improve dust levels. Figure 5 shows the WH at section 29 Brandspruit 2 shaft.

Fogger system at Thandeka mine

The presentation introduces us to the fogger system, which substitutes the water spray system with the vapour system of ultra fine water droplets (vapour), which promise to capture

Table III

Section Parameters and conditions

Section parameter	Condition
LTR velocity (m/s)	1,87
Type 24 Engart scrubber (m^3/s)	8
Water pressure (bar)	16
Water flow rate to the CM (ℓ/min)	130
Spray fan system sprays used	1.6 mm inlet; 2.0 mm outlet (hollow cone 'miner' sprays)
Pick sprays	0.8 mm outlet

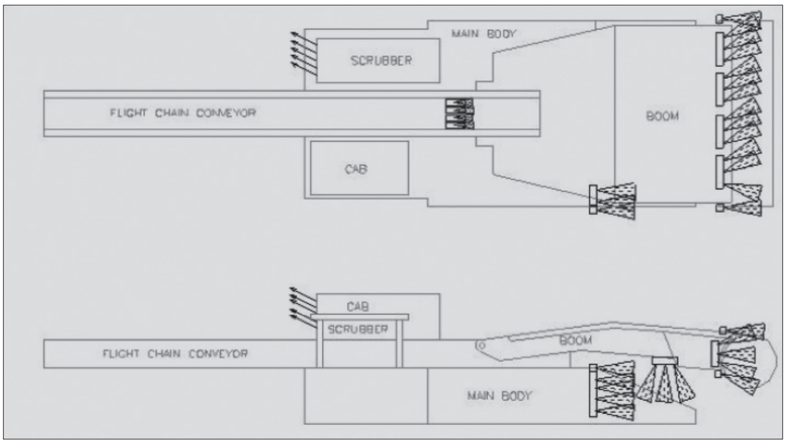


Figure 3—The directional spray fan system

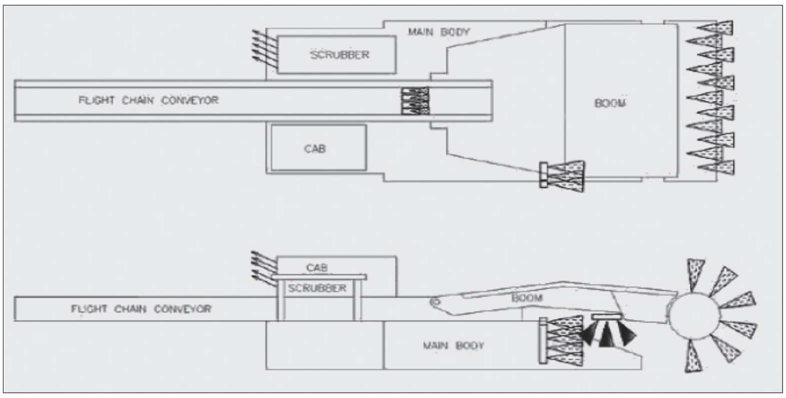


Figure 4—The wet head system on the right

more dust than water droplets. Tests were done at the Thandeka mine in October 2004 and they reduced dust concentrations by 96%. Figure 6 shows the results when the dust sampler was put 4 and 10 pillars downstream from the vapour sprayers. Thandeka mine used the system to reduce the amount of dust coming in from the intake airway. Another success story of the fogger system is at Greenside Colliery where it proved 98% effective.

The Envidroclear Fogger system uses the principle that if a water droplet is larger than the dust particle, the dust particle will go around the water particle and thus not be captured by the water droplet. However, if a water droplet is equal to or smaller than the water particle, the water particle will fuse with the dust particle and thus capture it. Figure 7 illustrates the working principle of the fogger system (Envidroclear Marketing Presentation). The dark irregular shaped particles represent the dust and the lighter oval is the water particle .

The significance of this information

Sasol Mining implemented the fogger system between August and October 2005 and it also proved to be quite successful. Sasol took the fogger system a step further by implementing it in the CM. Figure 8 shows the block arrangements on the CM

Results of the trial period of the fogger system are shown

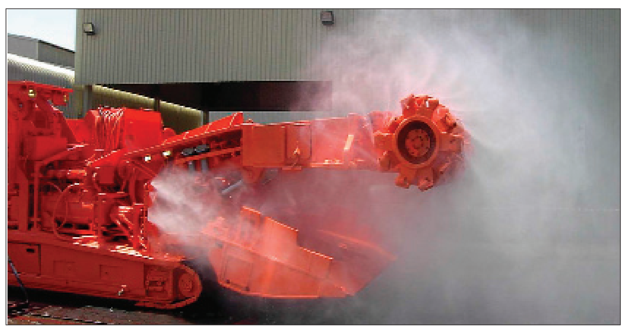


Figure 5—The WH at section 29 Brandspruit 2 shaft

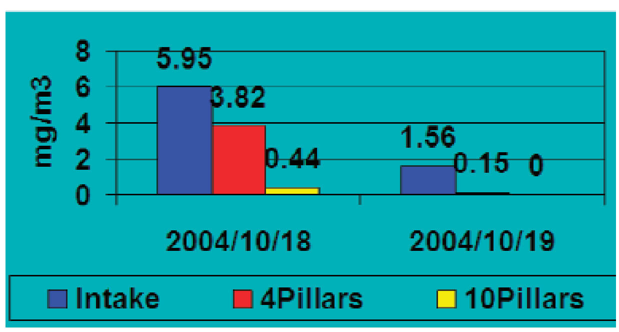


Figure 6—Effectiveness of fogger system when sampler is 4 and 10 pillars downstream

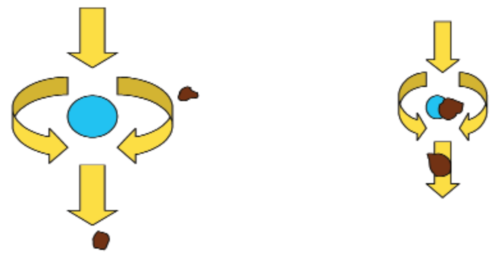


Figure 7—The working principle of the fogger system

later. What is also important about the fogger system is its effectiveness in intake airways; however, dust samples taken in intake airways at Sasol Mining averaged 0.6 mg/m^3 therefore the need for the fogger system in intake airways is not so great. The current control system in intake airways is wetting down of roads.

Results and analysis of results

Introduction

In this section data collected from Sasol Mining relating to dust are discussed in detail. All data collected were related to the objectives set for the project, as mentioned in Table II. Therefore the analysis follows the following sequence:

- ➤ personal sampling data to determine the danger zones for operators working underground
- ➤ data collected from new systems being used by Sasol Mining
- ➤ dust data from current control systems
- ➤ the sources of dust in a section and methods of suppressing the dust at the source.

Personal sampling data

This is a summary of the latest results of personal dust sampling. The sample analysis was done by Colliery Environmental Control Services (CECS) based in Evander, South Africa. The DME regulations stipulate that for a certain homogenous exposure group (HEG) of underground employees, the minimum frequency of personal sampling is every three months. Sasol Mining complies with this regulation and carries out personal sampling on all underground employees to determine the exposure limit of each personnel activity.

The groups that were identified as the most exposed from their dust sample results were shuttlecar operators, CM operators and roofbolter operators. This was due to personal sampling data, which was close to the OEL of 2 mg/m^3. A summary of the personal sampling data in Figure 9 shows clearly to which degree each operator is affected. From the figure it can be seen that the CM operator is affected the most by dust, therefore more care should be taken in reducing dust near the CM operator's position. These figures summarize personal sampling data for all the Sasol mines taken from February to August 2006.

A summary report from the Sasol Mining Medical Centre, where all Sasol employees get a medical examination, also indicated that the CM, shuttlecar and roofbolter operators were the most exposed to dust in the underground environment

The above data help in identifying danger zones in an underground environment, and there is no better way of determining those zones than to do personal sampling on people who actually work in those zones.

The following were identified as danger zones:

- ➤ The face where the CM operator is cutting. This information helps in determining the amount of dust monitoring and precautions that need to be taken on the face and also helps in the final design of a sustainable dust suppression system
- ➤ The transfer points where the shuttlecar operators work, usually behind the CM where coal is transferred from the CM to the shuttlecar and at the crusher where the shuttlecar offloads coal to the conveyor belts. Again this helps in identifying areas underground where extra monitoring and suppression of dust needs to be done.

New systems employed at Sasol mines

In this section an analysis is done on the results obtained from sections where trial periods were carried out on some of the new systems and technology introduced at Sasol Mining. The new systems include:

- ➤ the wet head cutter system
- ➤ the fogger system and
- ➤ the rear-exit scrubber.

The wet head cutter

The trial period was between November 2006 and March 2007 at Section 29 at the Brandspruit 2 Shaft. This is the first of its kind in the Sasol mines; previous trials were at the Goedehoop mine where the wet head proved to reduce dust by up to 50% but delivered no considerable increases in production (Van Zyl, 2005). Figure 10 shows the wet head

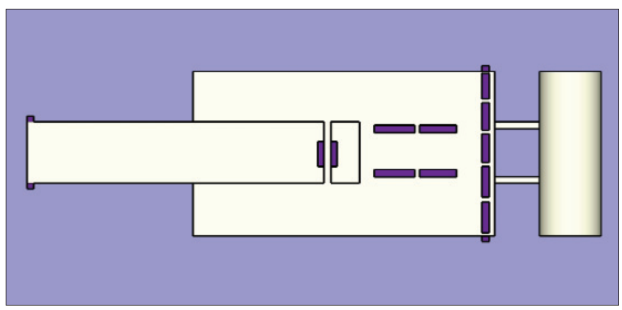


Figure 8—The block arrangements on the CM

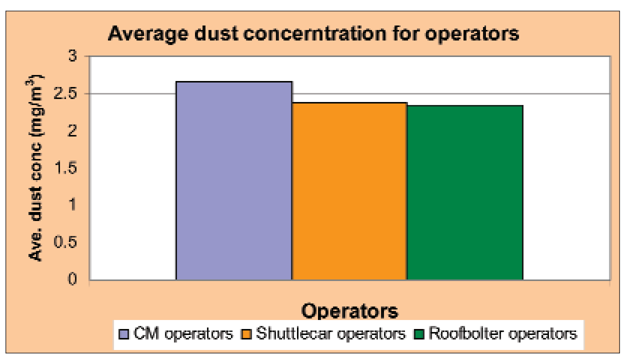


Figure 9—Personal sampling for Sasol mining operators

machine that was on trial at Brandspruit.

For Sasol Mining the wet head was analysed not only for its ability to reduce dust but also for certain other benefits that it has, such as:

- increasing productivity by increasing sumping and shearing rates
- decreasing pick consumption, which also affects productivity
- reducing fine coal production.

Figure 11 shows the complete results for a portion of the Wet Head trial period. The red vertical line on 3 November 2006 represents the commencement date for the wet head. After this date the average dust results were 1.8 mg/m³ until the end of the trial period in March 2007, which compares favourably with the personal exposure limit of 2 mg/m³ expressed over an eight-hour shift.

Other benefits of using the wet head cutter were the low rate of pick consumption because the picks are constantly cooled by the cold water from the sprayers, therefore the picks wear less. Changing of worn out picks take a considerable amount of time, which compromises production. Pick consumption results are shown in Figure 12. There is no benchmark for the ideal pick wear as it depends on rock conditions, cooling and operator skill, but any improvement in pick consumption is beneficial.

Other benefits are the rate of sumping and shearing, which affects productivity considerably. Sumping is the first horizontal cut into the rock by the CM drum and shearing is the downward cutting of the drum. Again there is no benchmark for cutting or shearing as this depends on rock strength and operator skill. Because the picks are always cool from the water cooling them, they cut and advance faster than that of a standard head CM. This is reflected in the results shown in Figure 13 and Figure 14.

There was less fine coal generated by the wet head because of the smaller pick spacing of 8.99 cm as compared to the standard head with 10.16 cm spacing. The importance of this is that there is less coal dust generated and that coal produced at Sasol mines is supplied to the Sasol plant where fine coal in undesirable.

The wet head has met all expectations and demands put on it. It is not a complicated machine and it received compliments from CM operators underground. It presents itself as a good option for a new system that can be successfully employed by Sasol Mining. It currently costs approximately R5.023 million, which is over double the cost of a standard head. A longer period of time is needed to evaluate whether the wet head results in a sufficient increase in productivity to justify its high capital cost.

The fogger system

The fogger system was investigated at Twistdraai East Section 86 between August and October 2005 and the results on test days are illustrated in Figure 15.

These results are from the return airway, which explains the high dust readings. The results prove that the system was highly effective. The fogger uses ultra fine water droplets, which have been proven to capture more dust than average size water droplets. The most important feature of the fogger is its versatility in that the system can be installed as a water curtain on the intake airway, as shown in Figure 16, whereas at some mines in the industry intake air can contain almost 2 mg/m³ of dust that comes from the intake airway and on

Figure 10—The wet head cutter

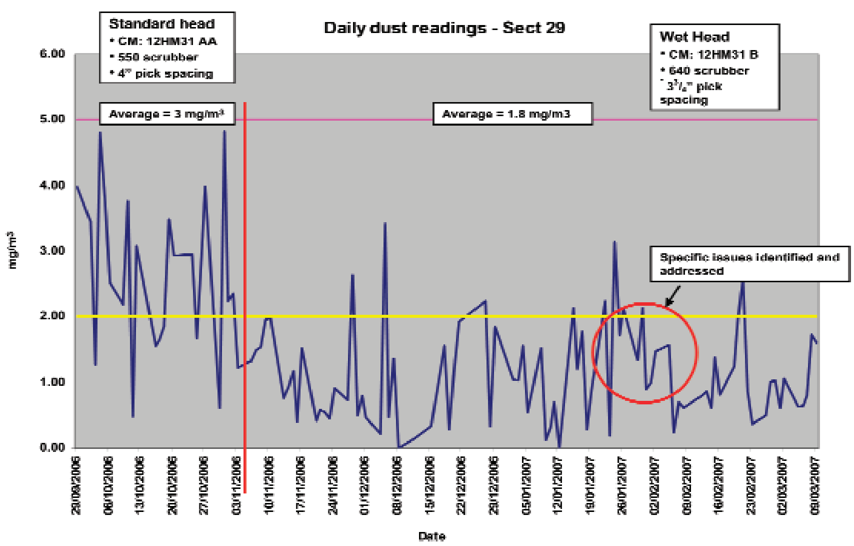


Figure 11—Results of the wet head cutter trial period

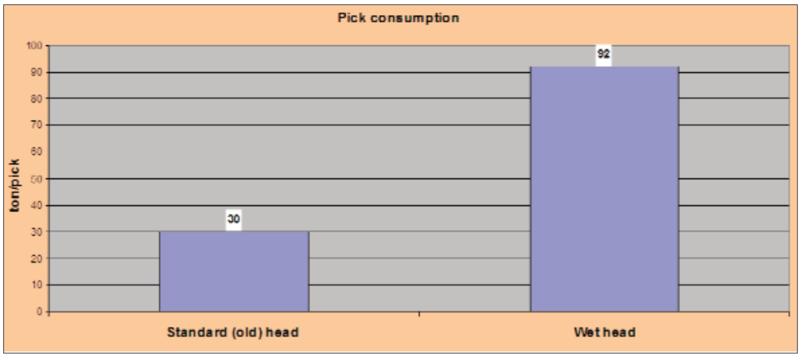


Figure 12—Pick consumption average results

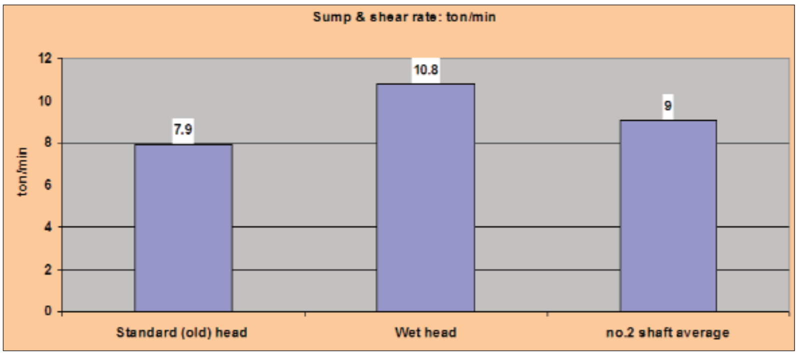


Figure 13—Sump and shear rates results

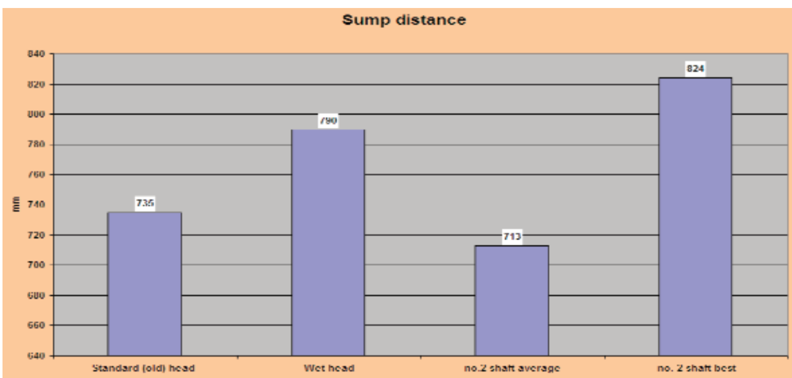


Figure 14—Sumping distance

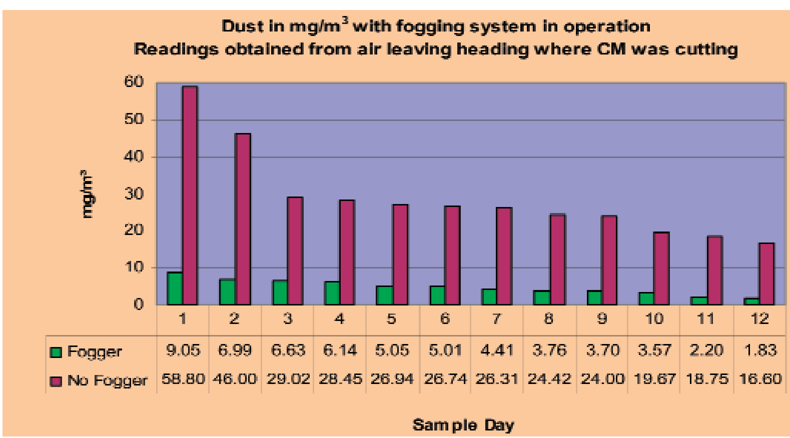


Figure 15—Dust readings with Fogger system

transfer points, as shown in Figure 17.

Limitations of the fogger system are the smaller nozzle diameters, which get blocked easily by dust and impurities in the water; therefore there is a need for the use of cleaner water so the filters are not blocked. During the trial period 30% of the nozzles were blocked, and on a CM this could cause loss in production if work is stopped to unblock the nozzles. Unblocking nozzles is a time-consuming task, that is why one of the recommendations would be to use the fogger system on intake airways and transfer points where there will not be a loss of production when the nozzles are being unblocked.

The rear-exit scrubber

This system is discussed earlier. It is different from the conventional scrubber with a side exit because it was proved that the side exit causes recirculation of air. The scrubber was also moved closer to the face, which is more effective because the closer the scrubber is to the face, the less the dust laden air will bypass the scrubber. The scrubber was also bigger than the normal 680 mm diameter scrubber in order to increase the surface area for dust suppression within the scrubber.

The scrubber was implemented at Syferfontein Colliery Section 29 for its trial period in January 2007, and Figure 18 is a summary of the results within its first week.

If the system is used properly and well maintained, the results are good. Figure 18 is inconclusive on the efficiency of the scrubber and further work needs to be done on it.

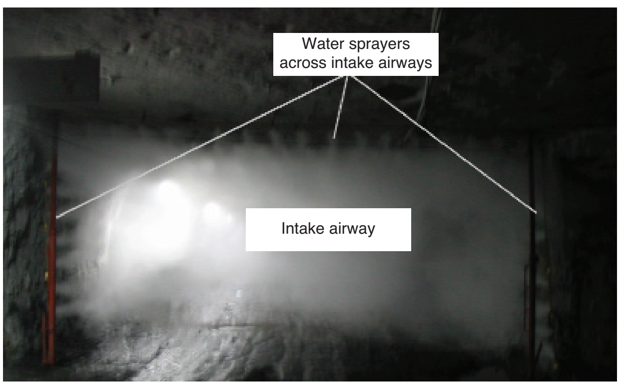


Figure 16—Fogger on intake airway

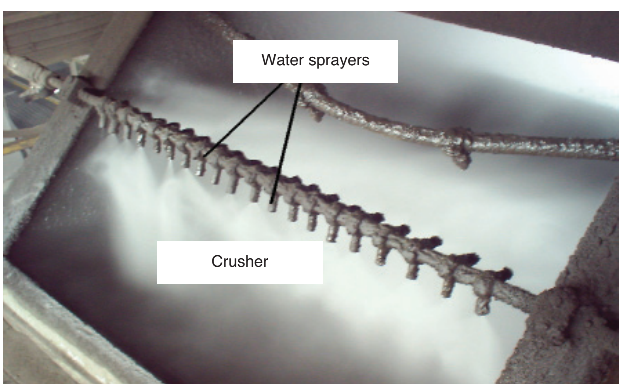


Figure 17—Fogger on transfer points

Dust results from current control systems

Twistdraai success story

Twistdraai is a success story of the mine's ability to control dust. This is due to a dust improvement plan by the mine implemented by management. This plan is discussed earlier, but basically it is the optimization of current systems, adequate training and proper governance that has made significant changes in the mine. Figure 19 shows the percentage of dust readings below 5 mg/m^3 for all sections before the dust improvement plan in July/August. From the graph it can be seen that the mine was at its worst, with only one section complying on both months.

Figure 20 shows the greatly improved dust results after the dust improvement plan. This was over October/November 2006. During these months more sections were complying with the 90% compliance directive. Even though the overall dust for the Twistdraai complex was not complying, the sections were doing well in keeping the dust readings low (Dust Improvement Plan, 2006).

From these results it can be concluded that existing systems and technology employed at Sasol Mining are

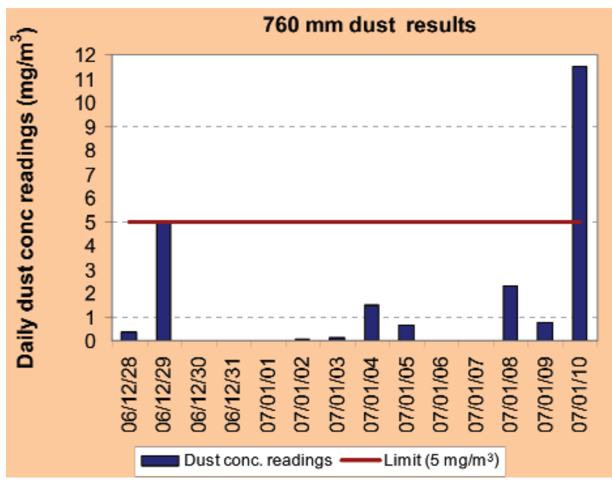


Figure 18—Rear-exit scrubber results

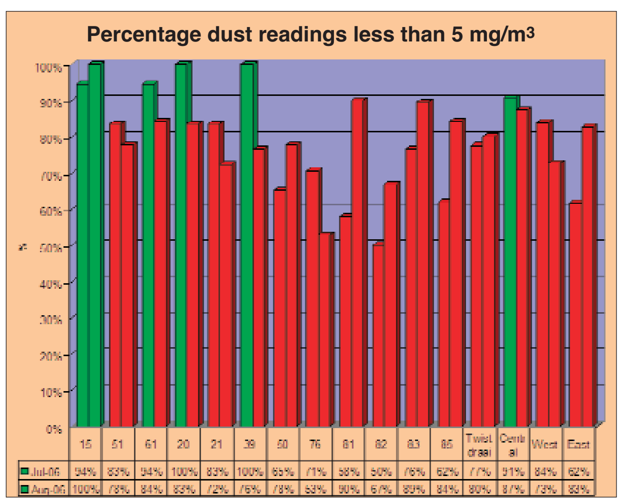


Figure 19—Results before the dust improvement plan

sufficient to control dust, therefore the focus should not be mainly on implementing new systems but:

- optimizing existing systems
- thorough training of staff and management
- on good leadership.

Syferfontein Section 92 success story

This section was the worst performing section in the whole Syferfontein mine in terms of dust throughout 2005. In December 2005, an analysis was done on the various components of the dust suppression system and how not following regulations increased dust readings. Table IV shows the state Section 92 was in during October and November. The figure shows that the section had managed to keep an average dust reading of less than 5 mg/m^3 only on 19% of the samples taken; this does not comply with the 90% compliance directive.

However, from 13 of December, all the components of the existing system had been in working order and proper training was done to educate workers about the need to take a proactive approach to dust suppression. The crux of the success of this section was proper maintenance of the existing systems and optimization of current systems that were already in place in the section. Potential downfalls of the section were as follows:

- The filters of the scrubber not being cleaned
- Sprays were blocked
- Picks were not kept sharp enough
- Some spray blocks were completely missing from the CM.

Therefore from 13 December missing spray blocks were welded onto the machine and training was done by the employees on how to maintain systems so they work efficiently.

After this the results started improving because of the awareness about dust hazards. This is shown in Table V and VI where compliance rose from 50% to a full 100%.

The Syferfontein success story also proves that the available resources and systems pertaining to dust suppression are enough. The main focus should be on optimizing the existing systems, training employees and proper management.

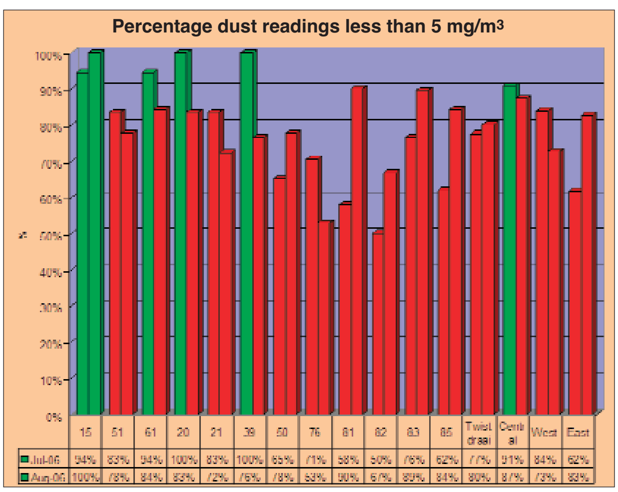


Figure 20—Results after the dust improvement plan

Analysis of the sources of dust

This section aims to highlight the sources of dust as identified through underground investigations and also to find ways to control the dust at these sources. Sasol Mining already has an approach to any risk control in the form of the Hierarchy of Control (Dust Training Manual, 2007), this section will go according to the hierarchy. The hierarchy of control is as follows;

- Suppression at source
- Engineering controls
- Administrative controls
- Personal protective equipment.

Table IV

Section 92 dust results

	Date	TWA $<5 mg/m^3$	Intake Dust	Compl. >90%
Section 92	26/10/2005	7.53		19%
	27/10/2005	9.65		
	28/10/2005	-		
	31/10/2005	-		
	01/11/2005	10.48		
	02/11/2005	11.81		
	03/11/2005	9.92		
	04/11/2005	4.04		
	07/11/2005	4.63		
	08/11/2005	14.74		
	09/11/2005	Discard		
	10/11/2005	7.25		
	11/11/2005	8.43		
	14/11/2005	15.17		
	15/11/2005	-		
	16/11/2005	No Dust		
	17/11/2005	9.21		
	18/11/2005	7.85		
	21/11/2005	6.28		
	22/11/2005	5.16		
	23/11/2005	1.23		
	24/11/2005			
	22/11/2005			
	Average	8.34		

Table V

Section 92 dust results

	Date	TWA $<5 mg/m^3$	Intake Dust	Compl. >90%
Section 92	28/11/2005	10.45		50%
	29/11/2005	3.63		
	01/12/2005	6.37		
	02/12/2005	0.11		
	05/12/2005	9.00		
	06/12/2005	16.41		
	07/12/2005	7.24		
	08/12/2005	6.00		
	09/12/2005	4.04		
	12/12/2005	5.86		
	13/12/2005	3.13		
	14/12/2005	2.27		
	15/12/2005	1.74		
	19/12/2005	0.25		
	20/12/2005	0.16		
	21/12/2005	7.73		
	Average	5.27		

Table VI

Section 92 dust results

	Date	TWA <5mg/m³	Compl. >90%
Section 92	27/12/2005	0.39	100%
	28/12/2005	3.92	
	29/12/2005	4.31	
	30/12/2005	3.24	
	03/01/2006	2.24	
	04/01/2006	4.50	
	05/01/2006	3.57	
	06/01/2006		
	Average	3.17	

Sasol Mining already has standards and dust control systems. Through underground investigations it was possible to highlight shortcomings of the systems and also ways of improving on the shortcomings.

Suppression of dust at source

Figure 24 illustrates zones identified as sources of dust circled in red. These areas represent areas where dust is newly formed and needs to be suppressed before it becomes airborne. Suppressing at the source is the most important part because airborne dust is difficult to suppress (Ondrey, *et al.*, 2002). These zones are identified as the sources of dust in a coal mining section. The various identified zones are:

Intake airways

Intake airways and travelling ways in general are a source of dust because of the high velocity of air in airways. The high velocity is for ventilation purposes. This high velocity raises already settled dust and makes it airborne. An investigation done at Sasol Mining showed that air coming into the section from the intake airway had an average of 0.6 mg/m³ of dust. Therefore the need for dust suppression in intake and travels airways is important (Ondrey, *et al.*, 2002). A cheaper option would be to wet down the roads as often as needed to make sure that the dust cannot become airborne. For the intake airways an installation of a fine spray water curtain close to the section would also be beneficial. The same method was used at Greenside Colliery with the Envidroclear fogger system and it proved highly effective. The water curtain is shown in Figure 16.

Cutting at the face

This is where the most dust is generated underground, therefore more efforts to reduce dust should be made at this area. Currently the Sasol mines use the directional spray systems integrated on the front of the CM. It is a good system but the problem arises when it comes to human involvement. The water sprayers on the CM are supposed to be arranged in the design shown in Figure 21 and the direction of the sprayers welded exactly as illustrated in the figure. This is to ensure that the maximum area of the face is covered by the water sprayers.

The nozzles of the sprayers get blocked due to impurities found in the water and dust particles, which get into the nozzles. The CM operator needs to stop the machine and inspect the sprayers and clean the sprays. This is a time-consuming process and usually, instead of rinsing the nozzle with high pressure water, the nozzle will be cleaned using a steel wire which opens the outlet diameter of water and makes the sprayers inefficient. It is important the outlet diameter of the nozzle is 1.6 mm to make sure that fine droplets of water are sprayed out. The recommendation would be the use of self-cleaning sprayers, which will avoid production loss due to unblocking the sprayers and also damage.

Blunt picks are also one of the main causes of high dust creation rates (Sasol Mining Induction Dust Training Presentation, 2005). Picks need to be sharp at all times, which is another labour-intensive process and also time consuming.

Transfer points

Transfer points are also a major source of dust underground. The main transfer points are:

- Behind the CM where the CM loads coal onto the shuttlecar
- Where the shuttlecar unloads the coal onto the feeder breaker
- On the feeder breaker where large pieces of coal are reduced in size
- On the conveyor belts.

A noticeable amount of dust is released when coal is discharged from the flight conveyor of the CM to the shuttlecar, and this puts the shuttlecar operator in a high exposure zone. A discharge cover made of pieces of conveyor belts has in the past shown good results (Belle, 2002). The discharge contains the dust from the flight chain of the CM and is positioned as shown in Figure 22.

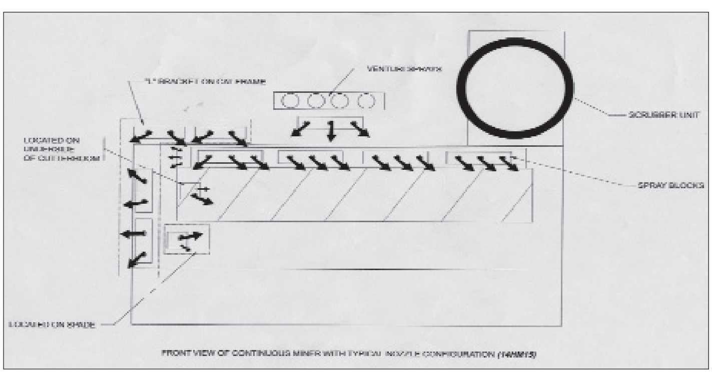


Figure 21—Arrangement of directional water sprays on CM

An integrated and sustainable solution to ensure in-section dust compliance

A water spray system is currently used at the Sasol Mining mines and the feeder breaker. From site visits, however, it was noticed that some of the sprayers were not working and showed signs of damage. Damage is seen by big water droplets instead of fine mist. Big water droplets do not effectively suppress dust because if the dust particle is smaller than the water particle, it will bypass the water particle. A recommendation in this case would be for good maintenance to be implemented.

The same applies for water sprayers on conveyor belts. Sasol Mining has a system in place for dust suppression in belts but if not well maintained the system might as well not be there. Figure 23 illustrates the belt dust suppression system.

Engineering controls

If the method of suppressing at source fails and the dust becomes airborne, the next step is to introduce engineering design controls, which will further suppress the dust that is airborne. Such methods include the scrubber and the basic ventilation control.

The scrubber

The function of the scrubber is to suck in dust-laden air and wet it down then let clean air be released on the discharge end. A typical scrubber unit is shown in Figure 25. In terms of design, it is important that the scrubber is as close as possible to the face to avoid dust bypassing the scrubber, or pieces of conveyor belts should be used above the scrubber to prevent the bypassing of dust. However, the scrubber can be effective if the dust filters within are cleaned regularly to unclog them. If the filters are not cleaned regularly they will not filter the dust-laden air efficiently.

A system should be designed such that when the CM finishes cutting a certain number of metres, and when the picks are being changed, the scrubber should also be cleaned. Also, instead of it being just the CM operators' responsibility to change picks, the other underground workers should help to make the process shorter and more effective.

Ensuring adequate ventilation is also important in the dust suppression system. Figure 24 shows a basic ventilation layout in a typical 7 road section. The average air velocity in the last throughroad (LTR) should be kept above 1 m/s and the minimum is 0.6 m/s (Sasol Mining Dust Induction Dust Training Presentation, 2005). These air velocities are crucial in coursing the flow of air and directing the dust to the return airways.

Administrative controls

Administrative controls employed by the Sasol Mining include:

- Dust training done at the induction centre
- In-section dust training
- COP for airborne pollutants
- COP for explosion prevention
- Dust suppression compliance audits and inspections
- Dust training manual, among many other initiatives.

Dust training should be done as frequently as possible to make people aware of the dangers of not keeping section dust under control. The start-of-shift meeting at the waiting place should include a brief dust training and reporting session (Dust Improvement Plan, 2006). The section miner should be well informed about the dust to train the rest of the team.

There is a dust reporting system that is available at the mine and is given to the CM operator daily. It is a good initiative in that it encourages the operator always to be

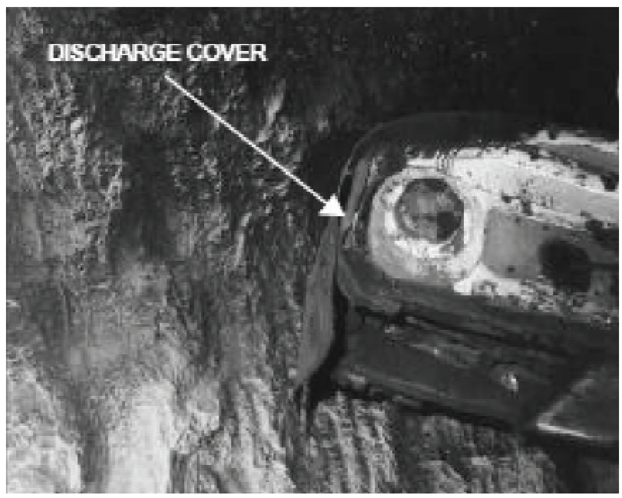


Figure 22—A discharge cover reducing dust at the CM discharge

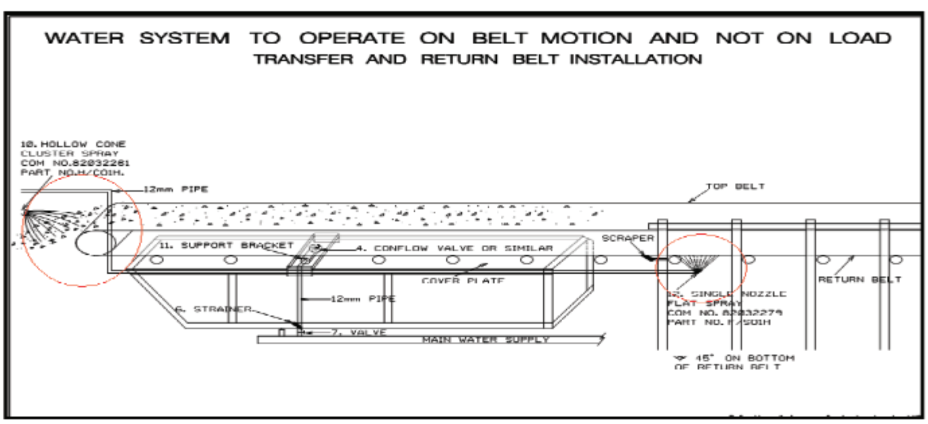
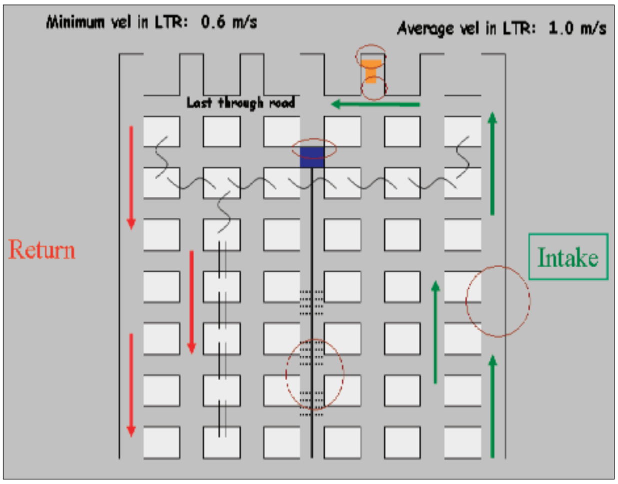


Figure 23—Belt dust suppression system



Figur 24—A typical 7 road section showing dust sources circled in red and basic ventilation

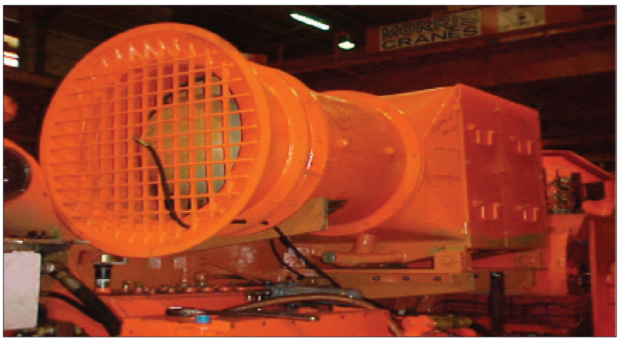


Figure 25—A scrubber unit

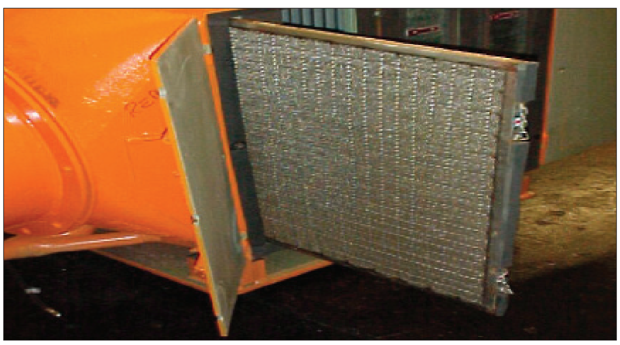


Figure 26—The filters of the scrubber

aware of factors that influence the dust. However, at times the report is not completed, partly because the checklist report is technical and time consuming to fill (Sasol Mining Induction Dust Training Presentation, 2005). The checklist is illustrated in Figure 27; the figure is the actual copy of the checklist. A simplified version of the daily checklist, designed and used at Syferfontein section 92 by Nozipho Mashinini, is illustrated in Figure 28. The checklist is efficient in that it is simple to fill in by using ticks and crosses, yet it makes sure that all issued are being addressed without confusing technical details. The technical aspects can be done by the section miner or shift boss.

The process of reporting should be made easy for the operators; this will ensure that they do report back. According to The Dust Improvement Plan the following should be the daily responsibilities:

- Reports sent out on a daily basis and feedback received at end of the day
- Daily audits done by production personnel are submitted with the fireman's report to the chief foreman to take action on all deviations weekly
- Environmental control department, when visiting a section, must do dust audits to rectify any deviations and then report the deviations to the chief foreman and mine overseer.

……………………..COLLIERY
DUST SUPPRESSION CHECKLIST
SECTION : DATE :

1	**Water system for mechanical miners**		
a	All lose dust, duff clogging and debris must be removed from the mechanical miner	Yes	No
b	Sprays as per COP installed	Yes	No
	(31 sprays, Spray positions on sketch)		
c	Booster pump working	Yes	No
d	Spray outlet all 2.0mm	Yes	No
	Spray inlet all 1.6mm	Yes	No
e	All sprays working	Yes	No
	(To be checked at beginning of shift	If blocked,how many…………………………	
	Were blocked sprays cleaned	Yes	No
f	Water powered air movers (3 air movers)		
	Installed	Yes	No
	Operational	Yes	No
g	Water pressure at spray nozzles in order	Yes	No
	(15 - 20bar)	Actual pressure as measured :…………bar	
h	Water flow rate through supply manifold in order	Yes	No
	(not less than 90l/min)	Actual flow rate as measured :……….l/min	
2	**On - board scrubber system**		
a	Scrubber working/damaged	Yes	No
	If not working or damaged, why……………………………………………………		
b	Inlet cone (Evasé) fitted to inlet of scrubber	Yes	No
c	Discharge deflector plates deflecting towards the left hand side	Yes	No
d	Scrubber filters cleaned or changed at start of shift	Yes	No

Figure 27—Daily checklist

Adequate ventilation in LTR	✓
Ventilation Walls up to date	✓
Brattices closed properly	✓
Correct fan placement and operation	✗
Scrubber maintained and cleaned shiftly	✓
Picks are sharp	✓

Figure 28—An example of the ideal checklist (Nozipho)

Personal protective equipment

Currently at Sasol mines dust masks are available to all workers on a daily basis but the underground personnel do not like wearing them because they are hot and make the air in the mask humid and difficult to breathe. To fully protect workers from dust these should be worn every day to prevent occupational lung diseases, which develops over a long period of exposure.

Conclusions

The chapter summarizes the findings that meet the objectives set in the beginning of this paper. It follows the sequence of the objectives as laid out in Table II.

Identification of the sources of dust in a section

The main sources of dust, as proven by dust results during the investigation, are as follows:
- ➤ The intake airway and travelling ways
- ➤ The transfer points behind the CM when it offloads onto the shuttlecar and where the shuttlecar tips the coal onto the feeder breaker
- ➤ The conveyor belt
- ➤ The face during the cutting of coal.

Investigation of current systems, their shortcomings and their effectiveness

Current control systems have proven sufficient to control dust if used and maintained properly. The main shortcomings of current systems are when maintenance is not carried out by the responsible individuals.

Personal sampling data analysis

Data obtained at the CECS and the Sasol Mining Medical Centre showed that operators most affected by dust are the CM, shuttlecar and roofbolter operators. This information helped in finding areas underground where more control of dust needs to be taken.

Finding sustainable solutions to ensuring in-section dust compliance

The most sustainable and integrated solutions were the optimization and proper maintenance of current systems which proved to be sufficient in dust suppression.

Recommendations

The most integrated and sustainable solution is the optimization and proper maintenance of current dust control systems. The following recommendations were discussed in detail previously; they go according to the hierarchy of control.

Suppressing at source

The following recommendations were made to suppress dust at the source:
- ➤ Wetting down of airways and the use of the fogger system in the intake airways
- ➤ Proper maintenance of the spray block on the CM (the CM is the major source of dust)
- ➤ Dust suppression at transfer points by use of discharge covers and water sprayers.

Engineering controls

- ➤ Proper maintenance of scrubbers
- ➤ Ensuring adequate ventilation at all times.

Administrative controls

- ➤ Effective and frequent training should be carried out
- ➤ A proper dust reporting system should be implemented.

Personal protective equipment

- ➤ Ensuring that the dust mask is worn at all times by employees.

Suggestions for further work

In order to build on the work already done in this project, the following are recommendations for further work.
- ➤ A cost-effectiveness study on implementing the wet head cutter throughout all Sasol mines. Can the high capital cost be justified by an increase in productivity? A longer trial period is needed to investigate that.
- ➤ A study into the effect of changing components of the dust suppression system on the other system components. A common mistake of mines is to change a component, such as the size of the scrubber, and not investigate the effect of this change on the other components.
- ➤ A design of a dust mask that is comfortable and can be worn throughout the whole shift, and will not affect productivity. Current dust masks are uncomfortable and inconvenient; they become humid after a short while and make breathing difficult. This is the reason why users discontinue use.

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